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Impacts of the Digital Economy on Manufacturing in Emerging Asia[1]

Jaewon Kim[*], Masato Abe[**], Fiona Valente[***]

Abstract The advent of digitalisation has transformed economies into more integrated, but increasingly complex systems. This new trend has brought dynamic changes in the manufacturing sector through advanced ICT infrastructure, smart factories, digitally-controlled logistics, and skilled ICT-labour. The impacts of the digital economy on manufacturing could be best illustrated through "Industry 4.0." With this wave of technological advancement, countries aim to establish an industrial ecosystem where every manufacturing process and function is connected and interacts through digital networks. Industry 4.0 presents opportunities for Emerging Asia, as the region has emerged as a fast-growing manufacturing hub and particularly a production base for ICT goods. However, growing production capacity, increased exports, and increases in FDI in the field of ICT goods manufacturing have so far contributed little to the development and diffusion of ICT. A huge gap exists in the ICT uptake amongst countries and between small and large firms. This paper highlights the level of Industry 4.0 readiness of Emerging Asia and key factors that determine its enhancement.

Keywords Digital economy, digitalisation, ICT, industry 4.0, industry 4.0 readiness, manufacturing sector, emerging ASEAN economies

I. Introduction

The world is rapidly changing, and new ways to interact, communicate, produce and distribute are rapidly evolving. The advent of digitalisation is reshaping economies to highly interconnected, but at the same time increasingly complex and dynamic systems. The digital economy has emerged as the latest

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[*] Investment and Enterprise Development Section, Trade, Investment and Innovation Division (TIID), United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), Bangkok, Thailand; jaewon.kim@mail.kmutt.ac.th
[**] abem@un.org
[***] valentefiona@gmail.com

driver of economic development, following the rapid advancement of information and communication technologies (ICT).

The digital economy is an economy where data flows are ubiquitous, and a profound transformation is taking place towards forging hyper-connectivity amongst people, groups, enterprises, and machines through ICT infrastructure and digital networks. Accounting for 22.5% of the global economy in 2015, the digital economy encompasses a variety of evolving components such as e-commerce (trading of goods or services through digital networks), digital infrastructure (hardware and software), digital workforce (skilled ICT-labour), digital supply chains (digitally connected industrial players, production facilities, and logistics service providers), digital security (security over digital assets), or even digital manufacturing (digitally connected and integrated production system) (Knickrehm et al., 2016).

This new trend exerts influence on society at several levels, ranging from the automation of business operations to the enhanced delivery of public services such as healthcare and education (Katz, 2017). It has brought dynamic changes, mainly in production processes in the manufacturing sector through the application and utilization of advanced ICT infrastructure and technologies. In the business world, such drastic changes have brought a new landscape to producers and service providers regardless of size or age of the firm, including those in Emerging Asia[2].

The manufacturing sector has led the economic development of Emerging Asia through commonly adopted and long-standing development strategies, i.e. the promotion of trade and foreign direct investment (FDI). This sector has created value, provided employment and generated income for people to escape poverty and lead a better life by producing a variety of goods such as processed foods, textiles, furniture, chemicals, metals, machinery, electronic apparatus, computers, automobiles, and recycled materials. Manufacturers in Emerging Asia, however, face intensifying competition due to multinational enterprises (MNEs)' attraction to more efficient sites for production relocation and business reorganization, while their understanding of the massive influence of digitalisation on future manufacturing is often very weak. Therefore, it is important that countries adopt comprehensive industrial, trade and investment policies to survive, or better yet thrive, under the ever-escalating competition in the digitalising manufacturing sector.

In a new era of digitalisation, the current change occurring in the manufacturing sector is best described as the emergence of the fourth industrial revolution, or namely, Industry 4.0 (McKinsey & Company, 2015). It is an industrial ecosystem that aims at higher productivity and efficiency through the

[2] In this paper Emerging Asia comprises the ten ASEAN member states, China and India.

increase of data flows and connectivity amongst industrial players and functions. This new ecosystem is based on smart factories that foster flexibility and efficient resource allocation in production through ICT integration in the entire process of manufacturing, or value chains. Industry 4.0 is based on the rapidly evolving ICT capacities, advanced analytics, connected machineries through the Internet ("Internet of Things" or IoT), and digitally-supported human-machine interactions (Deloitte, 2015).

The objective of this paper is to assess the impacts of the digital economy on the manufacturing sector in Emerging Asia and proposes policy options to increase the readiness of countries to thrive in this new digital economic system. The manufacturing sector was selected as this sector remains a crucial part of the region's economies, and is the major sector affected by current technological changes. As Emerging Asian countries need to transform their economies into digital ones, it is essential to understand how digitalisation is influencing this specific sector.

Against this backdrop, the paper first illustrates the present status of the manufacturing sector in Emerging Asia. Then, it describes the emergence and advancement of the digital economy and its impacts on manufacturing both at the global and regional levels. It briefly illustrates various concepts as well as opportunities and challenges that are expected to emerge from the ongoing development of Industry 4.0. The paper also reviews Emerging Asia's present policy frameworks and their gaps in getting ready to digital economy and fully transforming economies into Industry 4.0, and presents a list of key factors that determine digital economy readiness as well as policy recommendations with the aim to help countries reap the full benefits that could be derived from a digitalised manufacturing sector in Emerging Asia.

II. Trends in the Manufacturing Sector in Emerging Asia

The manufacturing sector in general contributes significantly to the economy in Emerging Asia. The sector accounts from slightly less than 10% (Lao PDR) to nearly 30% (China and Thailand) of GDP. With worldwide low growth in the manufacturing sector since the late 2000s global financial crisis, the contribution of the manufacturing sector to national economies is more or less stable or gradually declining in Emerging Asia, except for a few cases such as Myanmar and Vietnam. Myanmar has experienced a notable increase in contribution of manufacturing value-added since 2015 while Vietnam has maintained continued

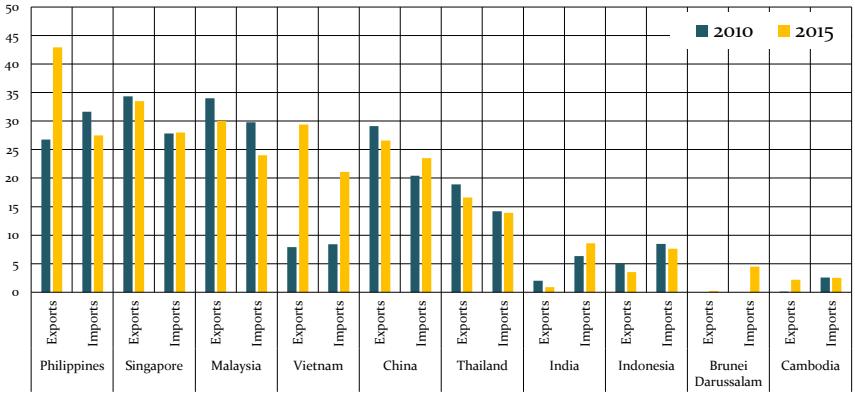
growth of quarterly manufacturing output since the first quarter of 2013[3] (UNIDO, 2017).

While China undoubtedly remains a dominant player in global manufacturing, other countries in Emerging Asia have seized opportunities to attract global manufacturing companies and present alternative production bases by offering more competitive labour costs. In the past few decades, the original five ASEAN member states - Indonesia, Malaysia, the Philippines, Singapore, and Thailand - have already established strong positions in regional and global value chains (RGVCs) of various products, such as food and beverages, chemical products, motor vehicles, rubber and plastics products, and office and computing machinery (UNIDO, 2017). Cambodia, Lao PDR, Myanmar, and Vietnam (often called CLMV) are also expected to further increase their manufacturing outputs, as they have strived to position themselves as intermediate goods suppliers, primarily in the export-oriented industries ranging from garment and footwear to computers and electronics. Garment manufacturers in Cambodia, Lao PDR, and Myanmar (hereinafter referred to as CLM countries), for example, have expanded their business opportunities in the United States and the European Union (EU), while Vietnam has made inroads into global electronics manufacturing (OECD, 2016a).

ICT goods, in particular, have been one of the most dynamic manufacturing subsectors for trade in many Emerging Asian countries. While China has been leading the market and accounts for around 32% of global exports of ICT goods, Malaysia and Singapore have been also listed amongst the top 10 exporting countries of the subsector (World Bank, 2016). The share of trade in ICT goods in total trade has exhibited an upward trajectory in most economies of the region as well (referring to the sum of merchandise exports and imports), which made it an emerging ICT goods production hub. ICT goods export in the Philippines, for example, marked around 43% of the country's total exports (figure 1). Vietnam has achieved a leapfrog growth in terms of the share of ICT goods export as well from approximately 8% to 30% within only 5 years during the period 2010-2015. Despite a slight decline during the same period, the share of ICT goods export both in Malaysia and Singapore remained at above 30%.

More specifically, most countries in the region have experienced an increasing export share of electrical machinery and equipment, apart from a slight decline seen in India and Indonesia (figure 2). The import share of electrical machinery and equipment also showed a gradual increase in many ASEAN member states, China and India. Particularly, Lao PDR's import share of electrical machinery and equipment goods almost doubled between 2012 and 2016.

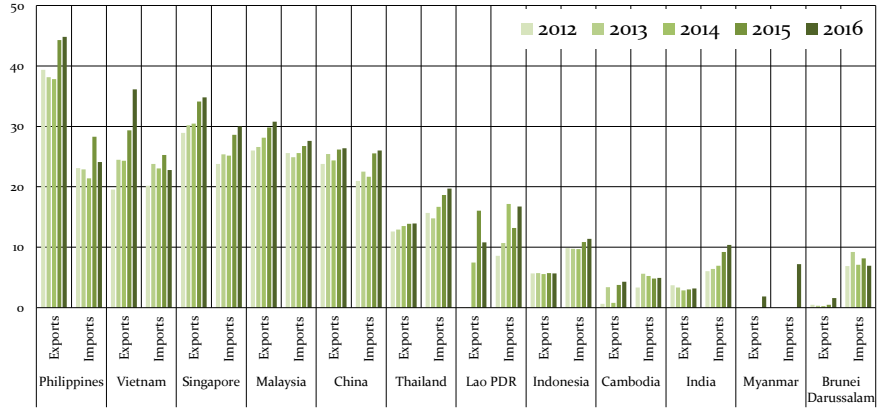
[3] As of the third quarter of 2017.



Source: The authors, based on UNCTAD data (2017) and World Bank World Development Indicators (2017).

Note: ICT goods in this paper refer to 93 products defined at the 6-digit level of the 2012 version of the Harmonised System (HS), including the broad level of categories of computers and peripheral equipment, communication equipment, consumer electronic equipment, electronic components, and miscellaneous.

Figure 1 Share of ICT goods, percentage of economies' total trade, 2010-2015



Source: The authors, based on ITC Trade Map data (2017).

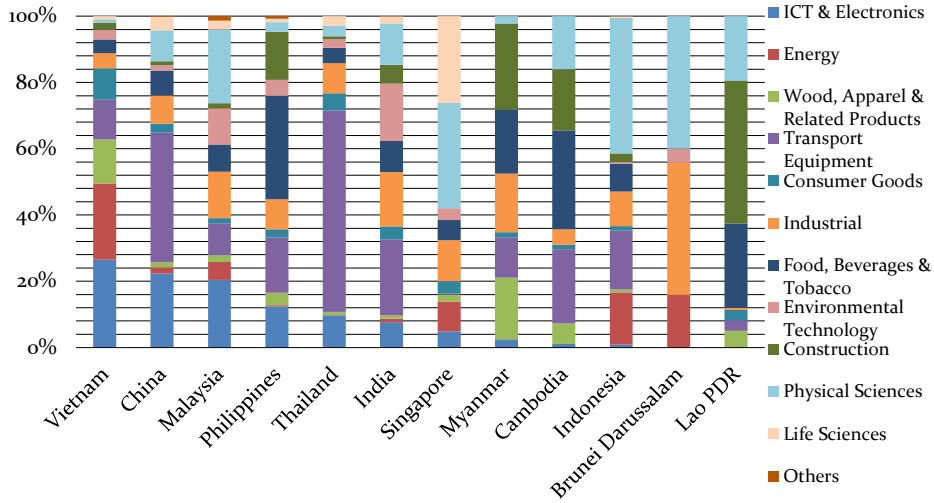
Note 1: HS Code 85 used in this Figure is described as electrical machinery and equipment and parts thereof; sound recorders and reproducers; television image and sound recorders and reproducers, and parts and accessories of such articles.

Note 2: Exceptionally only the 2016 data is available for Myanmar.

Figure 2 Share of electrical machinery and equipment in total trade, 2012-2016

The region's remarkable growth as an electronics and electrical parts production hub has been largely driven by the expansion of regional investment by MNEs (ASEAN Secretariat and UNCTAD, 2015; 2016). Its vastly improved manufacturing capacity as well as regulatory environment for FDI have led the region to position itself as an attractive alternative to the traditional production bases with rising labour costs. It has geared the recent relocation of the leading MNEs' manufacturing facilities for the production of such products as mobile devices, notebook computers and electric appliances.

Vietnam, for example, has recently emerged as a strategic destination for major high technology MNEs such as Samsung Electronics, Nokia and Intel to set up their manufacturing operations. Of total FDI attracted to the manufacturing sector, more than 25% was captured by ICT and electronics during the period 2012-2016 (figure 3). In the case of China and Malaysia, the subsector's share reached slightly above 20% while it was around 10% in the Philippines, Thailand, and India.



Source: The authors, based on fDi Markets data (2017).

Figure 3 Greenfield FDI in manufacturing by sector, 2012-2016

Given China's steadily rising overall labour costs and gradual move towards higher value-added industries, South-East Asia is poised to take advantage by filling the void. Vietnam, like Malaysia, has continuously reaped the benefits through the combination of growing production capacity and a surge of FDI inflows in the manufacturing sector. Although the sector is still in the nascent phase of development in the CLV countries, there are opportunities for these

countries to engage in the production of less complex ICT and electronic components.

III. Industry 4.0: A New Way of Manufacturing

The impacts of the digital economy on manufacturing could be illustrated through the concept of Industry 4.0 or, namely, the fourth industrial revolution. It is a new industrial ecosystem where every manufacturing and distributing process or function is connected and interacts through digital networks (Kagermann et al., 2011). A narrower definition of Industry 4.0 is the integrated production processes based on technologies and devices communicating autonomously along the value chains (Smit et al., 2016). This new wave of manufacturing is based on digitalised, or smart factories that enhance speed, flexibility, and efficient resources allocation throughout the entire production process. Industry 4.0 has also been driven by the exponential increase of data flows, connectivity, and digitally supported human-machine interactions (McKinsey & Company, 2015). After the concept was first introduced in the high-tech strategy of the government of Germany in 2006, it became widely known in 2011 as the government's strategic initiative, which gathered business, political, and academic representatives to enhance the competitiveness of the entire German industry (Bledowski, 2015; Kagermann et al., 2011).

The recent emergence of numerous disruptive technologies based on digitalisation has also accelerated the transformation of manufacturing operations into Industry 4.0. Disruptive, or relentless and unpredictable technologies, are defined as modern technologies that displace established technologies and change the industrial landscape or create a completely new industry (Christensen, 1997). Table 1 summarizes the examples and impacts of disruptive technologies to the manufacturing sector. Driven by the influence of disruptive technologies, combined with the constant and unrestrained exchanges of data through quality ICT tools, the manufacturing sector is now stretching beyond simple automation and is facing the emergence of new business models under Industry 4.0.

In particular, Industry 4.0 opens new chances for small and medium-sized enterprises (SMEs), by optimising manufacturing processes while reducing inefficiencies that have been often hardly manageable due to a lack of finance or skilled workers and helping identify potential partners in a more flexible manner with improved information tools. However, it is only the case when those SMEs possess absorptive capacity in terms of, for instance, entrepreneurship for the uptake of advanced manufacturing technologies. The majority of SMEs in reality struggle to embrace the rapidly evolving Industry

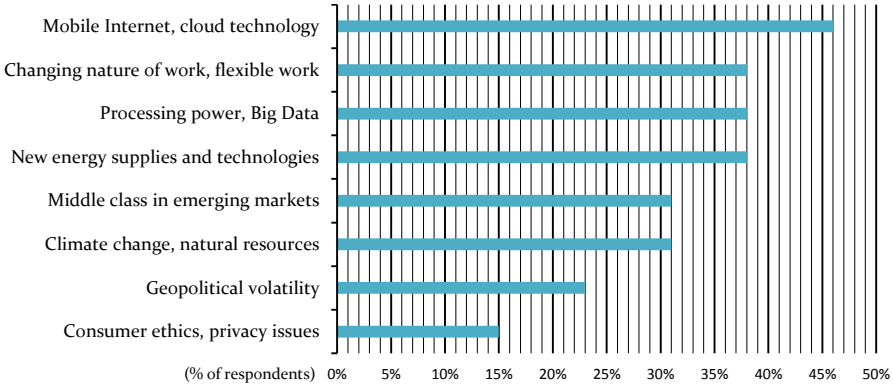
4.0 paradigm, however. Still many SMEs have not realised the significance of the impact of digital transformation and imminent changes in their business environment. Insufficient supporting infrastructure, limited access to a pool of highly skilled workers, and vulnerability to unstable cyber security are amongst the challenges faced by SMEs to thrive in the digital economy. Cognizant of the fact that SMEs are the backbone of not only the manufacturing sector but also the economy as a whole, a specific focus has to be given by the policy makers to formulate supporting mechanism for SMEs to be the integral part of Industry 4.0.

Table 1 Examples and impacts of disruptive technologies in the manufacturing sector

Functions	Disruptive technologies	Impacts
Data, computational power, and connectivity	Big data and open data	Significantly reduced costs of computation, storage and sensors.
	Internet of Things (IoT) and Machine to Machine (M2M)	Reduced cost of networks of sensors and actuators for data collection, monitoring, decision-making, and process optimization.
	Cloud technology	Centralized data flows and virtualized data storage by using computer hardware and software resources that are delivered over a network or the Internet, often as a service.
Analytics and intelligence	Digitalisation and automation of knowledge work	Advanced in artificial intelligence (AI) and machine learning through intelligent software systems that could perform knowledge work tasks involving unstructured commands and subtle judgments.
	Advanced analytics	Improved algorithms and largely improved availability of data.
Human–machine interaction	Touch interfaces and next level graphical user interfaces (GUIs)	Advanced in quick proliferation and consumer devices.
	Virtual and augmented reality	Made breakthrough of optical head–mounted displays (e.g., Google Glass).
Digital–to–physical conversion	Additive manufacturing (i.e., 3D printing)	Expanded the range of materials, rapidly declined prices for printers, increased precision/quality.
	Advanced robotics (e.g., human–robot collaboration)	Advanced in AI, machine vision, M2M communication and cheaper actuators, with increasingly capable robots with enhanced senses, dexterity, and intelligence used to automate tasks or augment humans.
	Energy storage and harvesting	Increased cost–effective options for storing energy and innovative ways of harvesting energy from renewable sources with reduced climate impact.

Source: The authors, based on McKinsey & Company (2015).

A move towards Industry 4.0 would particularly present potential opportunities for Emerging Asia who has increasingly significant manufacturing components. It is expected that by 2030, disruptive technologies associated with Industry 4.0 could reduce costs and increase profit margins, corresponding between US$25 billion and US$45 billion of economic impact per year amongst the countries in South-East Asia (Tonby, Ng and Mancini, 2014). McKinsey & Company (2018) estimates that productivity gains expected to be captured by ASEAN through Industry 4.0 worth US$216 billion to US$627 billion per year by 2025. The World Economic Forum (WEF) (2016a) also finds that key factors that are expected to impact future industries in ASEAN are closely related to digitalisation such as mobile Internet, cloud technology, flexible work, and Big Data (figure 4).



Source: The authors, based on World Economic Forum (WEF) (2016a).

Note: The figures were developed based on the result of an extensive survey with chief human resources officers and other senior talent and strategy executives of leading global employers, representing more than 13 million employees across nine broad industry sectors in 15 major developed and developing countries and regional economic areas (WEF, 2016a).

Figure 4 Factors impacting industries in ASEAN member countries

Emerging Asia is at a crossroads, facing rapid changes in the entire structure of manufacturing and supply chains. Boost in manufacturing productivity of leading adopters of disruptive technologies in developed economies would render Emerging Asia vulnerable to intense competition. Dependence on low wages alone without quickly addressing the impact of disruptive technologies and productivity improvement cannot ensure the region's position as an attractive manufacturing base. Although there was progress in overall productivity in statistical terms in many Emerging Asian economies over recent decades, manufacturing productivity still remains low across the region

(McKinsey & Company, 2018). For instance, Vietnam, who is being seen by some as a close rival to China in manufacturing, is 87% less productive than China with respect to daily output per daily wage (Ibid.).

While the region has gradually evolved as a global ICT goods production hub particularly, and the future benefits of disruptive technologies in the region would be obviously enormous, the reality is that such growing ICT-goods production capacity of many countries in the region has hardly contributed to the creation of the physical or institutional ground on which Industry 4.0 can be based. For example, physical ICT infrastructures including nationwide broadband communication networks and services are prerequisite for the digital transformation of not only the manufacturing sector, but also the society at large. However, the digital disparity, or the digital divide, in basic ICT access, use and affordability amongst countries in the region makes the breadth and depth of digital transformation increasingly uneven and leave many of them fall behind in the wave of Industry 4.0.

IV. Emerging Asia's ICT Readiness to Industry 4.0

Amongst many factors that form the foundation for Industry 4.0, ICT connectivity facilitated through digital infrastructure, including both wired and wireless broadband Internet and communication services, is a key pillar on which the digital transformation toward Industry 4.0 is based. However, the region's capturing of an increasingly large share of global ICT goods production by leveraging the low-cost manufacturing advantage has hardly contributed to the rapid diffusion in the use of ICT. In other words, the improvement of production capacity and the significant upsurge in FDI in the field of ICT goods manufacturing have had little to do with increased readiness for digital economy and Industry 4.0 in many Emerging Asian countries (Wigdor, 2013). It does not correspond with the earlier experiences of Singapore and North-East Asian countries such as Japan, Republic of Korea, and Taiwan Province of China where spillover effects from growing presence of ICT goods manufacturing consequently contributed to a substantially high rate of ICT diffusion into every aspect of their societies (Wong, 2002; Kagami and Tsuji, 2001; Wigdor, 2013).

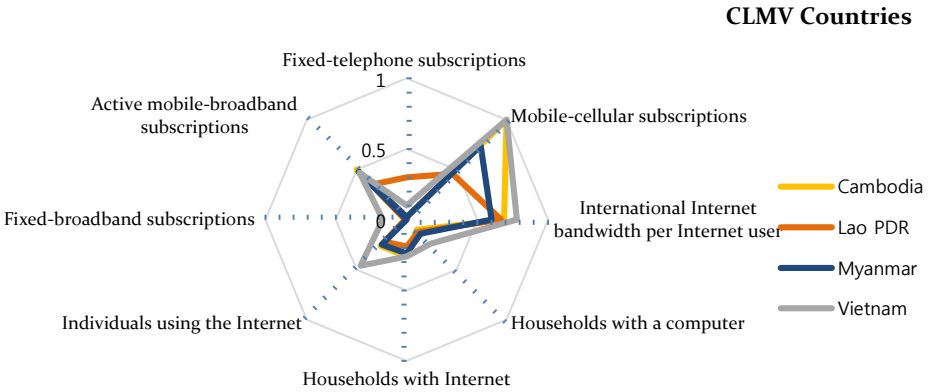
The ICT Development Index (IDI), which measures ICT readiness, intensity, and impact of the country, reveals that increased ICT manufacturing capacity in Emerging Asia does not necessarily coincide with each country's ICT production capacity (table 2 and figure 5). For example, the Philippines shows moderate achievement in the IDI, while its ICT goods trade captures nearly half of its total trade (see figure 1). In the same vein, a rapid and drastic increase in ICT goods exports in Vietnam does not seem to have brought a substantial

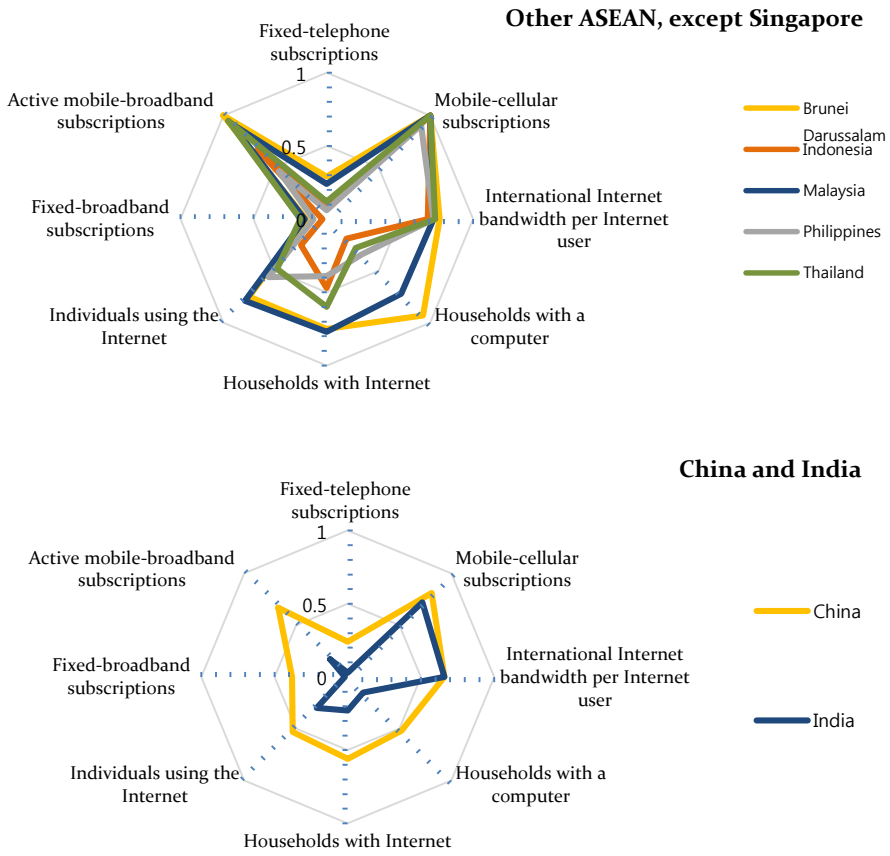
contribution to the adoption of ICT in the country. Between 2010 and 2017, its IDI rank rather slipped from 95 to 108, and the penetration and the quality of Internet services lag behind those of other major ICT goods manufacturers in South-East Asia. India and CLM countries also present a similar poor condition on ICT readiness.

Table 2 ICT development index (IDI), 2017, Emerging Asia

	Value (0~10)	Rank (out of 176 countries)
Singapore	8.05	18
Brunei Darussalam	6.75	53
Malaysia	6.38	63
Thailand	5.67	78
China	5.60	80
Philippines	4.67	101
Vietnam	4.43	108
Indonesia	4.33	111
Cambodia	3.28	128
India	3.03	134
Myanmar	3.00	135
Lao PDR	2.91	139

Source: The authors based on International Telecommunication Union (ITU) data (2018).
Note: Rank is from 0 (best) to 10 (worst).





Source: The authors, based on ITU data (2018).

Figure 5 Detailed components of the ICT development index (IDI), 2017

Looking at the penetration of ICT in managing day-to-day business operations, newly emerging ICT-goods manufacturing countries do not seem to leverage the potential as well. According to the 2016 Networked Readiness Index of the World Economic Forum (WEF, 2016b), technology absorption at firm level in Vietnam ranks 121 out of 139 countries, which is below Cambodia and Lao PDR (table 3). In terms of ICT use for business-to-business transactions, Indonesia and the Philippines still lag behind while their capacity for innovation rankings are relatively high. In the case of CLM countries, the situation is even more challenging. Myanmar is ranked 138 out of 139 countries in the overall business usage of Internet and ranked lowest in technology absorption at the

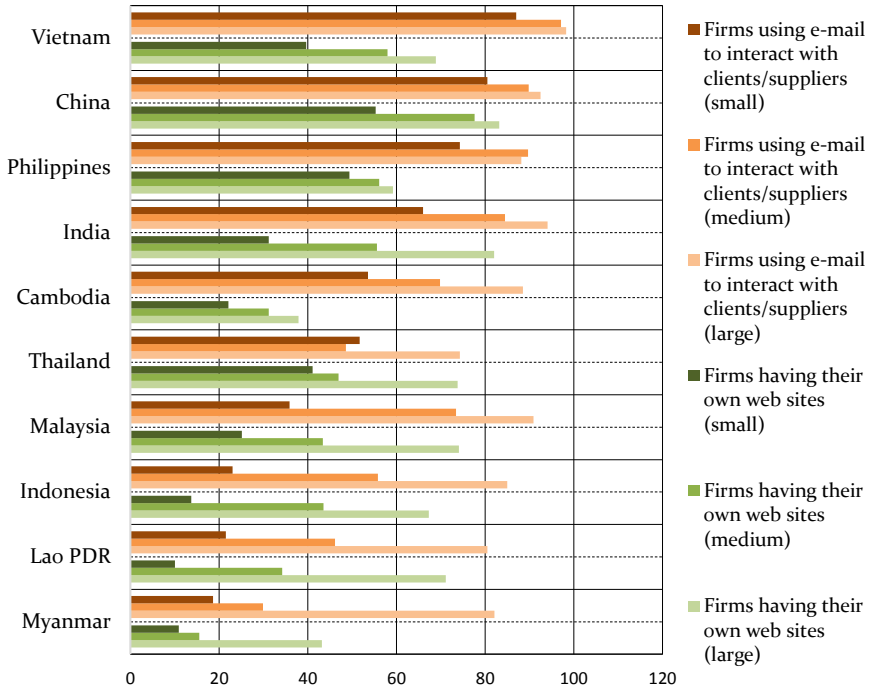
firm level. Cambodia and Lao PDR are also ranked amongst the lowest in all pillars of measuring networked readiness.

Table 3 Networked readiness index, 2016, Emerging Asia

	Overall business usage	Firm-level technology absorption	Capacity for innovation	ICT use for business-to-business transactions	Internet use for business-to-consumer transactions
Singapore	14	16	19	13	24
Malaysia	26	23	7	21	6
Indonesia	34	40	30	53	28
Philippines	36	41	33	58	51
China	44	66	49	57	32
India	51	102	50	108	77
Thailand	75	53	54	52	39
Vietnam	81	121	81	55	47
Lao PDR	89	96	89	97	95
Cambodia	104	97	113	82	98
Myanmar	138	139	136	137	127

Source: The authors, based on World Economic Forum (2016b).
Note: based on 139 countries, of which 1 is the best.

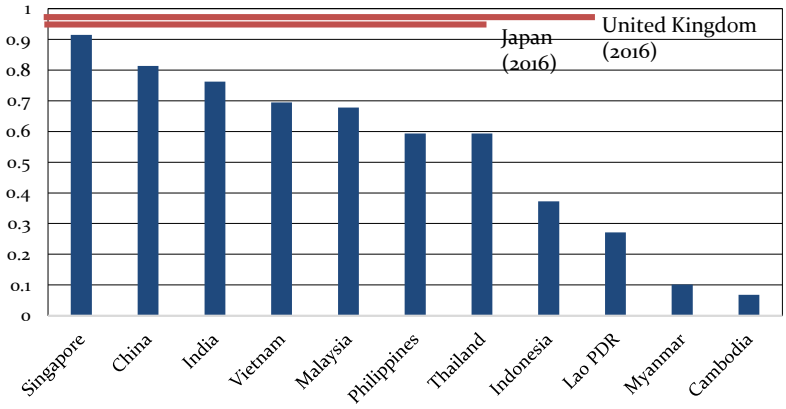
According to the results of the latest World Bank Enterprise Surveys (World Bank, 2017), the digital divide by firm size, especially with regards to readiness to the digital economy, poses serious challenges in many countries in Emerging Asia as well (figure 6). In the case of Malaysia, although businesses in the country have relatively well performed in using Internet and building firm-level capacity for innovation (see table 3), a severe gap exists in the usage of Internet in business operations between large enterprises and SMEs. This gap is particularly obvious in Indonesia where 85% of large firms use e-mail to interact with clients as well as suppliers while less than 25% of SMEs do, according to the survey. In Lao PDR and Myanmar, there is also much scope for improvement in terms of both promoting the use of Internet in business operations in general and closing the gap between large firms and SMEs in getting access to such technologies. In both countries, only around 10% of small firms have their own web sites and 20% use e-mail to contact business partners.



Source: The authors, based on World Bank Enterprise Surveys (World Bank, 2017).

Figure 6 Firm's digital economy readiness by firm size, Emerging Asia (percentage)

In Emerging Asia, digital interactions between governments and people also lag far behind those in developed countries. The United Nations' E-Participation Index, measuring governments' use of online services to facilitate sharing of information with citizens, interaction with stakeholders, and their engagement in decision-making processes, clarifies a capacity gap latent amongst countries in the region. Such a gap becomes more evident when compared to the extensive use of online tools by governments in developed countries (figure 7). In the Philippines, for example, government capacity in leveraging ICT is not proportional with its ever-growing manufacturing capacity for ICT-goods production. The gap between Indonesia and neighbouring countries with regard to ICT application in government services is also big. There is a need for improved governments' initiatives to provide citizens with easy access to information in handling public issues, which would not only diffuse technologies throughout the society in the most effective way, but also consequently facilitate digitalisation in the manufacturing sector.



Source: The authors, based on United Nations (2016)

Figure 7 E-Participation index, 2016, Emerging Asia

As the indicators above suggest, many emerging Asian countries do not demonstrate their ICT readiness for the digital economy and specifically Industry 4.0. A large gap exists between their capacities to produce ICT-related goods and to absorb ICT to enhance productivity and innovative capacity. The gap amongst individual countries and between small and large firms in terms of the uptake of ICT is also big. Opportunities driven by the expansion in local production capacity for ICT-goods may be outweighed by obstacles arising from being stuck on the lower rungs of the ICT value chain. It may be due to a lack of i) technological learning acquired through cumulative process of human resource development; ii) business infrastructure in the form of both 'hard' physical capital and 'soft' social capital; and iii) financial resources for the investment in new ICT technologies as aggressively as the advanced economies (Wong, 2002; p.168). Given the extent to which the new wave of technological advancement affects peoples' lives and society at large, measuring ICT-readiness for the digital economy or Industry 4.0 must cover various stakeholders in a broader sense, covering individuals, businesses and government. This is also important to help governments identify key factors necessary to enhance readiness to thrive in the new era of digitalisation.

V. Key Factors Influencing Industry 4.0 Readiness

Many countries in Emerging Asia have aimed to develop a productive, service-oriented, and digitalised manufacturing sector to achieve higher growth, increase the sector's contribution to GDP, create more jobs, and meet international quality standards (OECD, 2016a). Their ultimate objective is to

overcome the "middle-income trap" by fostering high value-added industries. Those countries have developed digital infrastructure such as increased broadband capacity, high-speed Internet connection, and advanced tele-communication systems, while enhancing cyber security (ASEAN Secretariat, 2016; Noor, 2015). They have also promoted SME modernization through upgrading and adoption of technology and R&D. They also work on the development of human resource to provide ICT experts to the manufacturing sector, including foreign investors. At the same time, they identified a need for sector-based industrial policy initiatives for the production of specific ICT goods such as AI, advanced sensors, integrated circuits, operating systems and industrial software, intelligent manufacturing and robotics (e.g., Thailand Board of Investment, 2016).

In order to maximize the benefits of digitalisation in the manufacturing sector, governments need to adopt developing strategies that range from upgrading both hard and soft ICT infrastructure to formulating favourable industrial policies and adapting education system. Our review of the digital economy and Industry 4.0 and the associated regulatory and policy frameworks in Emerging Asian countries suggests a number of key factors that determine digital economy readiness for a new way of manufacturing that can be categorized in six categories: (a) supporting industrial development policies; (b) ease of trading; (c) acquisition of applicable and affordable basic ICT infrastructure; (d) digital skills development; (e) FDI promotion and development of technology absorption capacities; and (f) enabling legal and regulatory environment.

1. Supporting Industrial Development Policies

Identifying and adopting industrial policy have recently regained currency, driven by multiple financial crises and emerging food, health, and the environmental challenges (WEF, 2016c). While systemic government inter-vention was generally needed to promote industrialization or to foster selected strategic industrial sectors (e.g., agriculture, apparels/garments, electronics, and automobiles) in the past, demand for government intervention now often comes from desire to develop specific industrial clusters or value chains involving multiple interdependent sectors and stakeholders across the border (Aiginger, 2012). It makes identifying and designing industrial policy more complex and comprehensive compared to the traditional clarification of whether it is horizontal or vertical.

In view of such changes in identifying approaches to industrial policy, it is crucial for policy makers to note that a broad number of variables are intertwined in formulating industrial policies to promote Industry 4.0, while Industry 4.0 particularly aims to upgrade the manufacturing sector to high value-added

through enhancement of uptake of digitalisation. In other words, policy makers must acknowledge that the impact of Industry 4.0 to the economy and society at large is tremendously far-reaching, with the emergence of new business structures as well as new forms of demand that may dismantle all part of an overarching framework of a country.

Therefore, while a newly-designed industrial policy adapted to Industry 4.0 may give preferential treatment to specific segments of the industry over others, it is essential to prepare measures to protect other segments that are vulnerable to the unfavorable impact driven from the rapid transition. For example, Industry 4.0 will launch a fundamental transformation in the structure of the labour market, as it is inevitable that many jobs will be replaced by automation. It will require extensive financial and institutional supports for SMEs for the deployment and management of costly technologies and high-skilled workers, or it will leave them far behind large firms who are capable of promptly adopting relevant technologies and mobilizing resources. An industrial imbalance amongst sectors or regions may also create a rift in trade and investment policies. This explains why Industry 4.0 in Germany, for example, directly involves the Ministry of Education and Research, the Ministry of Labour and Social Affairs and also the Ministry of Justice and Consumer Protection to deal with multi-dimensional issues arising from the emergence of a new way of manufacturing (Wolfgang, 2016).

Given the expanding scope of industrial policy, the key question for policy makers in countries where shift to Industry 4.0 is a prime target is to clarify a relevant approach or a group of approaches and adopt the right mix of policy options therein. Again, while Industry 4.0 specifically aims at reinvigorating the manufacturing sector, it has to be noted that other interlinked facets of economy from employment and education to foreign investment should be comprehensively reflected to a newly developed industrial policy.

2. Ease of Trading

Industry 4.0 stimulates data flows in an unrestrained way. Yet, this seamless flow of data and information must be processed to benefit value chains or their constituents or functions such as supply, production, and distribution. In this regard, the foundations of digitalised manufacturing and associated trade activities rest on an efficient logistics system and transport infrastructure. It is necessary to find the right logistic processes in terms of speed, cost, and reliability to facilitate accelerated trade flows using ICT and digital networks. Transport infrastructure, in the same context, must be improved to handle trade goods quickly and timely in line with enhanced information flows.

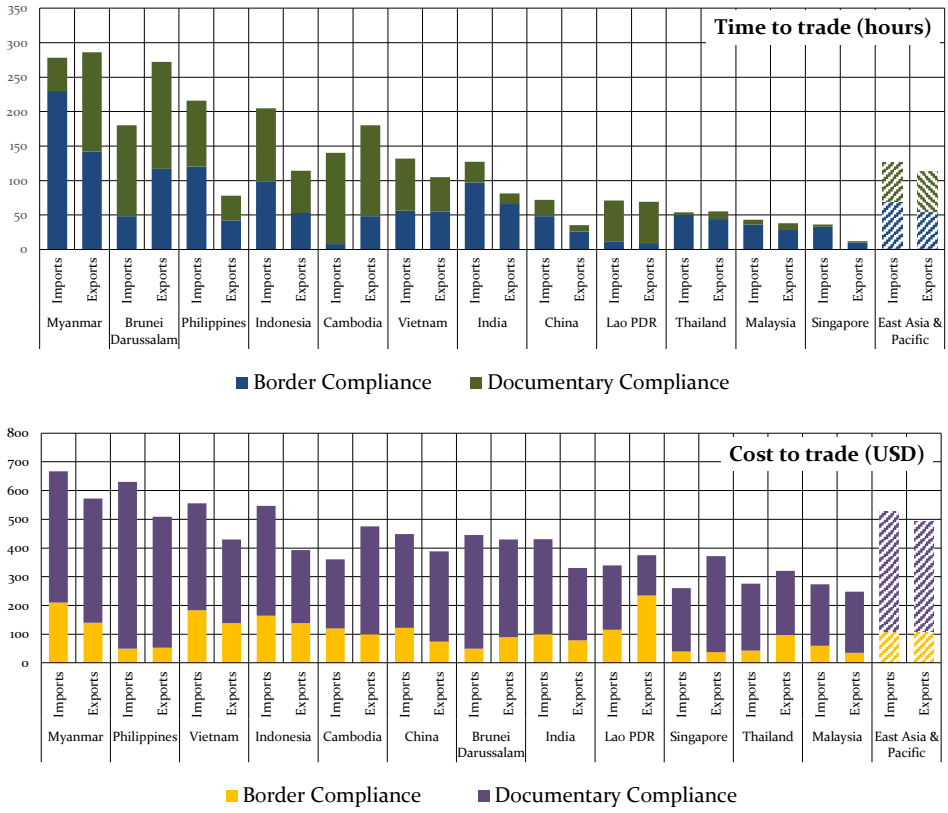
However, logistics and transport bottlenecks are still prevalent in Emerging Asia. The level of logistics development ranges from poor to good in the region, as there are vast differences between the transport infrastructure and logistics services amongst countries. Within ASEAN, Malaysia performs reasonably well and Thailand benefits from having the most sophisticated road networks and transportation facilities available, followed by Vietnam where infrastructure investment has led to the recent noticeable improvement. Further behind are Cambodia, Lao PDR, and Myanmar, which do not have access to well-developed transport infrastructure and have yet to make significant logistical improvements. The Logistics Performance Index (LPI) presented below suggests that many Emerging Asian countries are still in need of large investments for infrastructure and institutional development (table 4).

Table 4 Logistics performance index (LPI) in Emerging Asia, 2016

	Total LPI Rank	Total LPI Score	Customs		Infrastructure		International Shipment		Logistics Quality and Competence		Tracking and Tracing		Timeliness	
			Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Singapore	5	4.14	1	4.18	6	4.20	5	3.96	5	4.09	10	4.05	6	4.40
China	27	3.66	31	3.32	23	3.75	12	3.70	27	3.62	28	3.68	31	3.90
Malaysia	32	3.43	40	3.17	33	3.45	32	3.48	35	3.34	36	3.46	47	3.65
India	35	3.42	38	3.17	36	3.34	39	3.36	32	3.39	33	3.52	42	3.74
Thailand	45	3.26	46	3.11	46	3.12	38	3.37	49	3.14	50	3.20	52	3.56
Vietnam	48	2.98	64	2.75	70	2.70	50	3.12	62	2.88	75	2.84	56	3.50
Indonesia	63	2.98	69	2.69	73	2.65	71	2.90	55	3.00	51	3.19	62	3.46
Philippines	71	2.86	78	2.61	82	2.55	60	3.01	77	2.70	73	2.86	70	3.35
Cambodia	73	2.80	77	2.62	99	2.36	52	3.11	89	2.60	81	2.70	73	3.30
Myanmar	113	2.46	96	2.43	105	2.33	144	2.23	119	2.36	94	2.57	112	2.85
Lao PDR	152	2.07	155	1.85	155	1.76	148	2.18	144	2.10	156	1.76	133	2.68

Source: World Bank LPI data (2017).

In comparison to Singapore - a country that enjoys the most efficient time and cost to trade across borders - the total costs of preparing documents and handling customs regulations and mandatory inspections in other countries of Emerging Asia remain burdensome (figure 8). The large logistical burden in terms of both time and costs put on traders in Indonesia, Myanmar and the Philippines, for example, would be incongruent with other production processes, which are expected to be hugely expedited through digitalisation.



Source: The authors based on World Bank Doing Business data (2018).

Notes 1: The time and cost for border compliance include the time and cost for customs clearance and inspection procedures. The time and cost for documentary compliance include the time and cost for obtaining, preparing, processing, presenting, and submitting documents. The category East Asia and Pacific covers the following countries: Cambodia, China, Fiji, Indonesia, Lao PDR, Malaysia, Micronesia, Mongolia, Myanmar, the Philippines, Samoa, Thailand, Timor-Leste, Tonga, Vanuatu, and Vietnam.

Note 2: The most recent round of data collection by the World Bank was completed in May 2018.

Figure 8 Time and cost to trade, Emerging Asia, 2017

In improving logistics systems in Emerging Asian countries, the dematerialization of trade information and data utilizing ICT applications instead of using paper-based documents, commonly referred to as paperless trade, is expected to significantly save compliance costs and time (Duval and Mengjing, 2017). Paperless trade measures can be developed in forms of, for example, electronic single window system, electronic application and issuance of trade license, electronic submission of customs declarations or sea/air cargo

manifests, and E-Payment of customs duties and fees (Ibid.). Acknowledging the importance of digitalisation in transport and logistics services, many Emerging Asian countries have made progress in adopting and adjusting electronic trade platforms. For instance, the National Single Window (NSW) system[4] is currently operational or in progress in all twelve countries, while being at the different stages of preparation. As part of ongoing efforts to promote economic integration, ASEAN member states have also strived to connect each NSW by building the ASEAN Single Window (ASW).

Box 1 The national single window (NSW) of Thailand

Since 2011, the Thailand NSW has been implemented to facilitate international trade by reducing time and transaction costs through data integration on import, export, and logistics. The NSW is the 4th strategic agenda of Thailand's logistics development policy as well as crucial part of the ASEAN Single Window (ASW) initiative. In 2014, the NSW system of Thailand officially linked both national and international data and activated the cross-border information sharing. The NSW system allows traders to submit a single electronic document that include data preparation, customs declaration, and duty payment for the release and clearance by the customs. Both government agencies and business communities can perform permit and license-issuing procedures through the online system, and the information is digitally exchangeable amongst all partners without paper formalities. As of 2016, 26 national agencies including the Thai Customs Department and the Board of Investment of Thailand established complete data linkage to all types of trade documents for all kinds of goods electronically (ASEAN Single Window Portal, 2017).

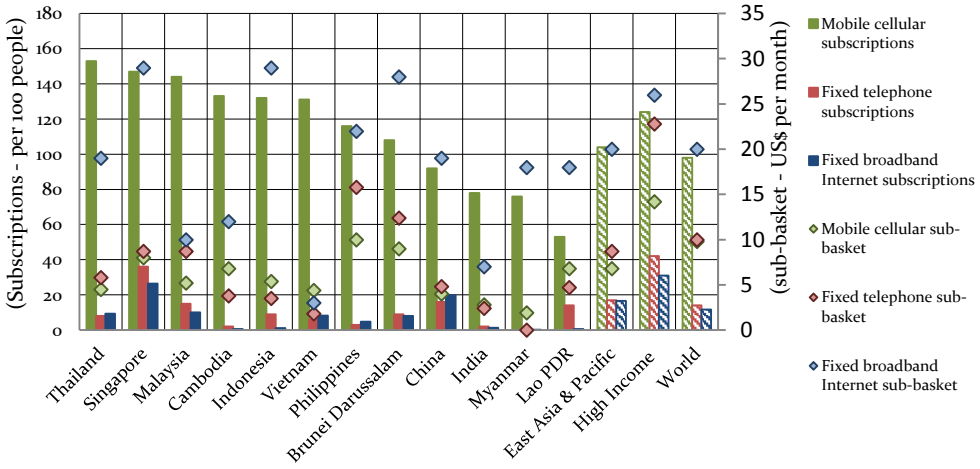
3. Acquisition of Applicable and Affordable Basic ICT Infrastructure

The development of an enabling environment for Industry 4.0 is not without costs. Indeed, large investments are needed to develop the required ICT infrastructure to succeed and stay competitive in the digitalisation era. To achieve the pervasive diffusion of highly advanced core digital technologies for Industry 4.0 such as Big Data analytics and cloud computing, it is prerequisite for a country to provide applicable and affordable basic ICT infrastructure. Lack of basic ICT infrastructure, and especially those related to "connectivity" including broadband connectivity, that are efficient and widely accessible is considered one of the factors that prevent major ICT goods manufacturing countries in Emerging Asia from becoming digitally advanced. While ICT infrastructure encompasses not only a device or technology itself, but also

[4] National Single Window system refers to a single electronic gateway through which all trade related documents required by a large array of different regulatory agencies can be submitted in a integrated manner and all relevant trade data can be accessed.

standards, management, and others, one of the fundamental issues is to make it affordable for all businesses or individuals to access and utilize[5].

Looking closely at the current environment in terms of connectivity, mobile cellular subscriptions, for example, are far below the global average in India, Lao PDR and Myanmar (figure 9). Especially in Lao PDR, mobile cellular subscriptions per 100 people remain slightly above 50 while those in Singapore and Thailand are around 150. Except Singapore, fixed-broadband Internet subscriptions in all ASEAN member states, including the ICT goods manufacturing countries such as the Philippines, Thailand, and Vietnam lag behind the regional and global average. In terms of affordability, in general, fixed-broadband Internet sub-basket is notably high in many countries in the region. For example, fixed-broadband Internet sub-basket of Indonesia is even higher than that of high-income countries.



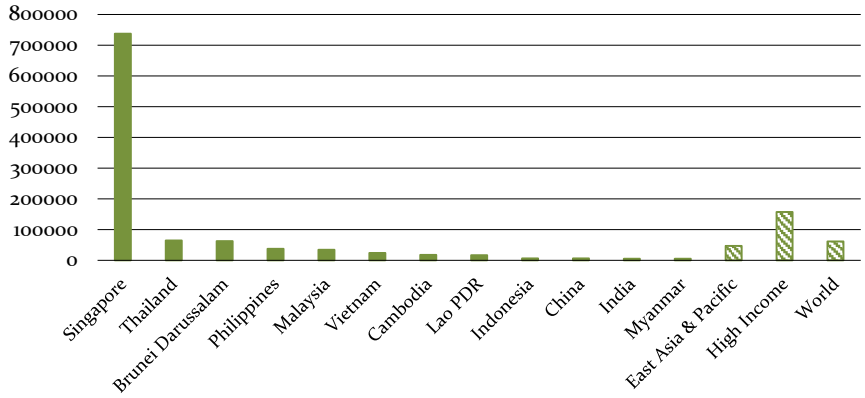
Source: The authors, based on World Bank World Development Indicators (2017).
Notes: All legends represent data of 2015, except the "fixed telephone sub-basket" data of 2014.
The category East Asia and Pacific covers the following countries: Cambodia, China, Fiji, Indonesia, Lao PDR, Malaysia, Micronesia, Mongolia, Myanmar, the Philippines, Samoa, Thailand, Timor-Leste, Tonga, Vanuatu, and Vietnam.

Figure 9 Telephone and Internet connectivity and affordability in Emerging Asia

In terms of quality of access to the Internet, which is often presented with bits per second per Internet user, there is much to be improved in most ASEAN

[5] SMEs, in particular, cannot afford high costs for digital devices and Internet (e.g., cost of Internet per speed), and at the same time, they cannot afford technological upgrading in their operations.

countries, where the average speed is considerably low compared to the high subscription costs (figure 10). In the case of China it is also worth noting that Internet access speed is poorer than in most of the neighbouring countries, including Lao PDR. This implies that while the region has made huge strides towards the development of quality and affordable ICT services, investment in telecommunications and Internet-related infrastructure will remain a key policy priority to maximize the benefits from the digital economy.



Source: The author based on World Bank World Development Indicators (2017).

Figure 10 Internet quality in Emerging Asia: bits per second per Internet user

4. Digital Skills Development

Industry 4.0 is expected to create a skills gap amongst present workers by adopting automation and digitalisation in the production processes. Disruptive technologies are also expected to bring substantive and lasting changes in the nature of work, which correspondingly will affect the associated jobs. For example, repetitive tasks may be done by robots, while several production stages in the assembly line could be removed by using 3D printing, and AI could lead to a reduction of many foremen and supervisors on manufacturing lines. As a result, the skills required in digitally-sophisticated manufacturing operations are rapidly changing (box 2).

At the same time, the demand for relevant skillsets and job qualifications is expected to open new opportunities for workers under the digital economy. According to recent research on the industrial workforce under Industrial 4.0 in Germany, it is estimated that approximately 210,000 new jobs would be created in ICT, analytics, and R&D fields, with about 70,000 industrial data scientists and 40,000 robot coordinators in the country (Boston Consulting Group, 2015).

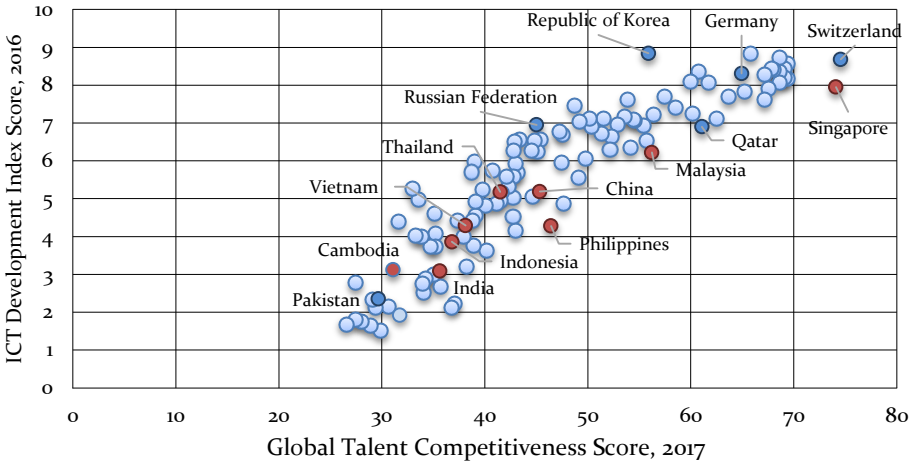
Box 2 New skills required in the digital economy

An OECD report on necessary skills for a digital economy affirms that the use of digital technologies will raise the demand for three varieties of new skills:

- Generic ICT skills: workers across an increasing range of occupations need to acquire generic ICT skills to be able to use such technologies in their daily work, e.g., access information online or use software.
- ICT specialist skills: the production of ICT products and services – software, web pages, e-commerce, cloud, and big data – requires ICT specialist skills for programming, developing applications, and managing networks. It is based on the ability to interact with ICT interfaces.
- ICT complementary skills: the use of ICT is changing the way that work is carried out and raising the demand for ICT-complementary skills, e.g., the capability to process complex information, communication with co-workers and clients, problem solving, and planning.

Source: OECD (2016c).

While factors affecting the levels of digitalisation vary, human resource development is doubtlessly one of the most fundamental bases that lead the advancement in digital technology, and reversely, increasingly sophisticated and complex technologies provide opportunities for highly skilled and educated workers. Figure 11 shows there is a clear correlation between the level of human capital and the level of ICT development in a country. It strongly suggests that both educational system and labour policy go hand in hand to produce talented human resource and facilitate on-the-job training and entrepreneurship to enable countries to swiftly adapt to a new digitized environment (INSEAD, 2016).

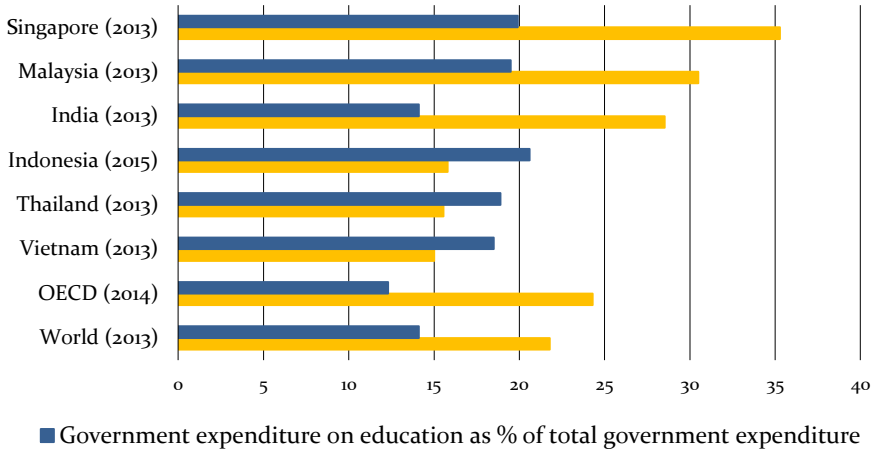


Source: The authors, based on INSEAD (2016) for Global Talent Competitiveness Score and ITU data (2018) for ICT Development Index Score.

Figure 11 Global talent competitiveness versus ICT development index

Accordingly, relevant adjustments are required in national education systems throughout all levels of learning and training, and government investment must be allocated in a more systematic way to be better aligned to new skill requirements for the future workforce under the digital economy. While firms are responsible for providing employees with reskilling and upskilling training opportunities to stay adaptive and flexible, public support to education in ICT- and digitalisation-related areas is imperative to comprehensively build an environment for building a technical or science-oriented capacities and qualifications of the workforce that are needed for more sophisticated digitalised manufacturing.

Thus, governments' investment in higher education must be revisited in some countries. The share of government expenditure on tertiary education out of total expenditure on education in Indonesia, Thailand, and Vietnam still lags behind that in their neighbouring countries and the global average, even though their investment share in education is generally high (figure 12). Whereas education at all levels does affect one's capability in absorbing and utilizing technology, tertiary education must be given special attention as it has a direct substantial impact on workers skills and knowledge to survive in the digital economy. Although public spending is not the only requirement for improving enrolment rates and the quality of higher level of education, there is a need for policymakers to invest more in higher education in addition to vocational education and professional training.



Source: The authors, based on World Bank data (2017).

Figure 12 Government expenditure on education, selected Emerging Asian countries

5. FDI Promotion and Development of Technology Absorption Capacities

FDI is arguably one of the most effective channels for delivering technology spillovers in Emerging Asia, which, in turn, help a country transform itself to digital economy overtime. An emerging country with relatively low ICT capacity is likely to capture less chance to internally finance high ICT infrastructure. Gholami et al. (2005) highlight that FDI inflows can induce investment in ICT infrastructure of the host country. Tan and Leewongcharoen (2005) also argue that the rapid development of the ICT sector of Thailand is attributable mainly to technology and human resource spillovers from inward FDI. The technology transfer induced by FDI inflows thus has a significant impact on the ICT sector in the host country.

The digital economy in Emerging Asia is likely to be fostered by enhanced technology transfer through combined trade openness and FDI facilitation. There are some success stories in the region in this regard. The growth of China, Malaysia and Singapore, and later Thailand and Vietnam as leading global ICT suppliers and exporters has been largely supported by trade openness and effective attraction of FDI to the ICT sector (Shirazi et al., 2010). Economic reforms implemented in these countries during the mid-1990s induced massive FDI inflows and increased trade, contributing to flows of technology and ICT-related skills to the host countries. China, in particular, fostered its ICT sector by reducing trade barriers on goods with industrially significant technology, which contributed to providing the country with the necessary human capital as well as technology to expedite its success in the sector (Tan, 2004). Singapore has also successfully maximized the utilization of inward FDI and ICT goods imports to develop its domestic ICT sector since the 1970s (Gholami, et al., 2005). Technology transfer resulting from FDI and imports of advanced ICT goods could help a country foster its ICT/electronics production capacity, in particular when effective linkages between foreign investors and domestic companies can be forged.

Emerging countries in Asia may also implement a geographically-focused strategy to attract FDI to the ICT goods sector and import ICT-related technology utilizing special economic zones (SEZs). SEZs contain clusters of geographically-concentrated and related industries and companies that help diffuse technology and human capital amongst them. As such, in many cases SEZs play an active role in fueling technology spillovers through FDI and trade. For example, Thailand has emphasized the importance of the creation of "super clusters" that use advanced digital technology amongst participating firms to leapfrog growth of its ICT sector (Thailand Board of Investment, 2015). This

SEZ/cluster strategy can strengthen ICT investment and enhance associated ICT spillovers.

6. Enabling Legal and Regulatory Environment

Finally, the manufacturing sector must protect its data from cyber theft and data leaks under Industry 4.0. Manufactures must also find the right equilibrium between their own need to collect data throughout their value chains and the suppliers' or consumers' desire to keep their information confidential and private. There has been a persistent concern over seamless cross-border data flow, especially in terms of ensuring security (or safety and privacy), or protecting and benefiting local businesses from harsh competition in the global markets. The unrestricted opening-up of data and the cross-border circulation of personal data pose risks such as breaches of digital security, unauthorized uses of sensitive personal data, and intellectual property (IP) infringements (OECD, 2016b). The open nature of the Internet that inter-connects users in real time can also magnify the harm to individual privacy, for instance, through transmission and storage of sensitive personal information, across the border with uncontrollable speed before any action is taken. The Internet and unrestricted data flow also entail the loss or destruction of data, which could happen both accidentally and deliberately in today's stiff competition (UNCTAD, 2016).

In this regard, emerging countries in Asia are at higher risk, as in many cases data protection and privacy laws are not systematically developed, while online activities have been boosted by rapidly expanding Internet connectivity and technology. It is also challenging to balance privacy with security when formulating laws and regulations for data or privacy protection, as loose protection might reduce consumer confidence while overly stringent protection could adversely isolate businesses from the global markets (Ibid.). Another issue in the context of the interconnected nature of the Internet is that even if certain regulations to protect data or personal information exist, they vary considerably from country to country. In this regard, there is a need for further international cooperation to build a coherent and harmonious framework for data protection.

VI. Conclusions

In Emerging Asia, the manufacturing sector has led the economic development by providing goods, creating jobs and values, and generating incomes under commonly-adopted and long-standing trade and investment promotion policies and strategies. Presently, the digital economy has brought a new landscape to the manufacturing sector driven by technological progress,

such as new ICT infrastructure, smart factories, digitally connected and controlled logistics, and skilled ICT-labour. The advent of digitalisation has reshaped manufacturing to a highly interconnected but at the same time increasingly complex and dynamic system.

This new wave of the fourth industrial revolution presents opportunities for new manufacturing hubs in Emerging Asia to enhance its production capacity to an unprecedented level. While having successfully attracted global investors who seek for competitive ICT goods production base, however, the region has not been keen on leveraging the potential benefits accumulated through extensive ICT-related manufacturing activities. Many emerging countries of the region still find it extremely difficult to utilize the accumulating ICT goods manufacturing skills and expertise to diffuse ICT applications into every aspect of the manufacturing process.

Key prerequisites that ensure effective diffusion of new ICT technologies, including so-called disruptive technologies, in the context of Industry 4.0 range from fundamental factors such as formulating and implementing pertinent industrial policy and improving infrastructure to more substantial factors such as investing in education and training to foster digital workforce and ensuring digital security. The key challenge particularly for ICT-goods producing countries with growing manufacturing capacity is to develop and harmonize essential but multidimensional requirements in promoting their transition towards the digital economy and to maximize the expected benefits in a more sustainable way.

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